Approaches to nuclear fuel assurance

Balancing nonproliferation with energy security

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Nuclear fuel assurances are the formal promises that international suppliers extend to consumers of nuclear fuel for the twin purpose of meeting energy security needs and discouraging the proliferation of nuclear weapons. This article examines various international perspectives on the implementation of fuel assurances and suggests that a supplier's unilateral ability to solve either problem may be far more limited than is commonly believed. The relevance of fuel assurances in future international regimes for nuclear energy will be dependent upon the future structure of the nuclear market and the political linkages that are made between energy security and nonproliferation commitments.

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Countries that operate nuclear reactors, whether for research or power generation, are sensitive to the possibility that the fuel for these reactors might one day be cut off or interrupted by foreign suppliers. One way an importer might deal with this problem is by seeking an independent ability to supply this fuel through the development of national facilities for reprocessing, enriching and breeding nuclear fuel. Yet as these technologies are enormously expensive and produce fissile material suitable for the manufacture of nuclear weapons, most importers have to rely on formal promises from suppliers that fuel will be provided on a timely, reliable and economic basis. These promises, called nuclear fuel assurances, constitute a major element of ongoing international efforts to pursue the twin goals of energy security and nonproliferation.

This article will identify five regimes now under international discussion for the provision and disposition of nuclear fuel and will specify the likely effects of these arrangements on nuclear nonproliferation and energy security. It will discuss the emerging international consensus on the potential of nuclear fuel assurances to solve these problems and will argue that this consensus is based on some dubious assumptions about the impact such measures can have in either area. To the extent that fuel assurances will play an important role in any of the five regimes, this role will most probably be limited to certain special circumstances as discussed below.

An emerging consensus on fuel assurances

Recent discussions in several diplomatic arenas are revealing a growing international consensus, shared by nuclear suppliers and consumers alike, on the pivotal role that nuclear fuel assurances will play in the regime to govern future international commerce in nuclear technology. The most visible institutional expression of this consensus is the International Atomic Energy Agency's (IAEA) Committee on Assurances of Supply, which met in Vienna in September 1980. Nuclear fuel assurances were also key topics at recent conferences of the nuclear industry (Amsterdam,

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London and Mexico City in autumn 1980), meetings of international research groups such as the Rockefeller Foundation's International Consultative Group on Nuclear Energy, NASAP and INFCE,[1] the Second Review Conference of the Nonproliferation Treaty (NPT) in August 1980[2] and recent conferences of Heads of State of Non-Aligned Countries (eg Havana, September 1979). Specific US initiatives emphasizing fuel assurances are contained in Title I of the Nonproliferation Act of 1978.[3] Further illustrations of the wide international importance attached to fuel assurances are provided in the statements cited in Appendix 1.

The basic idea of fuel assurances as a tool of nonproliferation policy was formally enunciated in the US Atomic Energy Act of 1954, but has been subsequently used by suppliers to encourage adherence to the NPT and restraint in developing sensitive technologies such as enrichment, reprocessing, heavy water facilities and breeder reactors. According to a former US State Department spokesman for nonproliferation,

> no principle was recognized earlier and was more important to the development of the current nonproliferation regime than the need to provide dependable fuel supply assurances to other countries.[4]

The linkage between fuel assurances and energy security is based on a variety of political and technical considerations concerning the operation of the international market for nuclear technology. Developing countries, which will have an estimated installed nuclear capacity of 27 GWe by 1990,[5] are increasingly aware of the importance of secure sources of supply. The industrialized world is also concerned, especially in light of a projected 150-250 GWe nuclear capacity for OECD countries by the same year.[6] The USA alone now has 298 contracts for enrichment services with domestic and foreign utilities, most of which extend into the next century, with a present value of $75 billion.[7] Thus, for a combination of economic and security-related reasons, both importers and exporters of nuclear fuel see fuel assurances as an attractive means of reinforcing energy security while discouraging proliferation.

Five international regimes

It is one thing for countries to agree on the centrality of fuel assurances in the wider international regime for nuclear power, but quite another to build a consensus on the policies required to implement the notion. A brief survey of recent literature on nonproliferation reveals no less than 16 different measures currently being advanced under the rubric of nuclear fuel assurance (see Appendix 2). Ranging from renegotiated bilateral guarantees to allocative schemes involving a global authority, all of these measures attempt to strike a balance between energy security and nonproliferation. The diplomatic challenge thus lies more in reconciling different national interpretations about where this balance should lie than in the establishment of fuel assurances in the nonproliferation regime. In various combinations, these separate measures form the bases of five regimes for the international market in nuclear fuels, with each regime differing in terms of the amount of central international coordination required.

Centralist regimes

In the early days of nuclear power (1946), the USA, the UK and Canada favoured the creation of an International Atomic Development Authority (IADA) with the highly centralized tasks of owning and operating all sensitive steps of the fuel cycle. The monopolistic role of the IADA has been echoed in supranational provisions of the EURATOM Treaty and, most recently, the American proposal for an International Nuclear Fuel Authority (INFA). At the opposite extreme, a far more decentralized approach is embodied in the free market commercialism of the 'Atoms for Peace' period, and more recently, with the liberal nuclear trading positions taken by would-be nuclear suppliers in the developing world, such as India, Argentina and Brazil.

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[1] The International Nuclear Fuel Cycle Evaluation (INFCE) was a two year international assessment of the dangers of proliferation posed by various nuclear fuel cycles. It was proposed by President Carter in his nuclear energy policy address of 7 April 1977 and took place between October 1977 and February 1980. The American input into this review was supported by the Nonproliferation Alternative Systems Assessment Program (NASAP).

[2] See Marsha M. McGraw, 'The NPT review conference', *Arms Control Today II*, February 1981.

[3] Text available in US Congressional Research Service, *Nuclear Proliferation Factbook*, 96th Congress, 2nd Session, Government Printing Office, Washington, DC, September 1980, pp 71-84.

[4] Myron B. Kratzer, Testimony before the US House of Representatives Committee on Science and Technology, Subcommittee on Energy Research and Production, 5 June 1980.

[5] Thomas J. Connolly *et al, World Nuclear Energy Paths*, Rockefeller Foundation, New York, 1979, p 40. (A GWe, or gigawatt, is a billion watts of electric power).

[6] Chauncey Starr and Chaim Braun, *Supply of Uranium and Enrichment Services*, paper presented to ANS/ENS/AIF Conference, Washington, DC, 18 November 1980, Electric Power Research Institute, Palo Alto, 1980, p 3.

[7] Ruth M. Davis, *Commercial Enrichment Services and Supply Assurance*, paper presented at Atomic Industrial Forum/ Dutch Atomic Forum, Conference on the Nuclear Fuel Cycle, Amsterdam, The Netherlands, 15 September 1980, p 10.

The most centralist regime in effect replaces the fuel 'market' with a centrally directed arrangement linked with the idea of 'global resource management'. In this view, uranium (like many other scarce minerals) is too sensitive strategically and too valuable economically to be allocated on the basis of *ad hoc* transactions. Resources should be mined, brought to central processing centers, organized on a regional or global basis and then distributed to customers depending on a variety of conditions. These conditions would include the country's economic need and its international reputation *vis-à-vis* nonproliferation. The proposal for INFA has been supported in the US Congress by Representative Jonathan Bingham and Senator Charles Percy, who is now chairman of the Foreign Relations Committee.

The mercantilist regime

As states are reluctant to sacrifice national sovereignty over their resources, a second means of allocating fuel supplies has evolved. In accordance with principles deeply embedded in European economic history, a mercantilist market structure was developed during the postwar breakdown of Anglo–Canadian–American nuclear cooperation and subsequent scramble for uranium. Mercantilism prevails when key consuming states cultivate exclusive trade relationships with specific producing states, often ex-colonies, involving the exchange of finance and technology for raw materials. A clear illustration of this pattern is seen in the economic ties between France and its former African colonies, especially Niger and Gabon.

The two-tiered regime

Another means of assuring nuclear fuel supplies is found in the US Nuclear Nonproliferation Act (NNPA) of 1978. This scheme departs from the bilateral or regional arrangements associated with mercantilism and sets forth a two-tiered market structure permitting some nuclear fuel activities (eg reprocessing, breeding, enrichment and plutonium storage) in some countries while denying them to other countries. The act attempts to discourage the national development of sensitive nuclear technologies in non-weapons states, and prefers international control or concentration of these activities in weapons states. Several features characterize this system: a predominant leadership role for the USA; the formalization of technological discrimination between non-weapons or 'proliferation-sensitive' states and nuclear weapons states; the continued financial and technological dependence of less developed states on the advanced states; and the continuing horizontal dependence of the latter on American leadership. Title I of the NNPA thus promises fuel assurances only to 'those nations and groups of nations which adhere to policies designed to prevent proliferation'.

The modified two-tiered regime

Amid international discussion of this approach following the conclusion of INFCE, a modified two-tiered scheme for fuel supply has been favoured by spokesmen of nonproliferation policy in the Carter administration and the UK Atomic Energy Authority. Like the preceding scheme, this approach reserves certain sensitive nuclear activities to states that satisfy the twin requirements (as set by the advanced nuclear states) of demonstrable economic need and assured peaceful use. A central feature of this approach is its purported 'evolutionary' nature: virtually all states can become eligible for inclusion in the upper tier, but only after they have reached a high level of economic and technological development while also maintaining good nonproliferation credentials. Until these importing states attain this level of development, however, they must continue to rely upon fuel assurances extended by existing suppliers.

The three-tiered regime

Finally, a three-tiered market structure has emerged from recent meetings of non-aligned nations that hope to acquire the ability to supply advanced nuclear technology and fuel services. As conceptualized by Argentina, Brazil and India, a small group of less developed but technologically independent countries will abandon the two-tiered market and deal directly with new nuclear customers.

The prime motivation of countries supporting this arrangement is to escape what many states perceive as discriminatory elements of the two-tiered scheme and unilateralism in the establishment of the rules of the nuclear fuel game. The three-tiered market structure has been advanced in recent meetings of the 'Group of Non-Aligned Coordinating Countries on Peaceful Uses of Nuclear Energy' held in Belgrade in December 1978, Havana in 1979 and in Buenos Aires in summer 1980. As stated in one of their communiques, the group stresses:

> . . . the need for extensive cooperation among the nonaligned and other developing countries with the aim of achieving self-sufficiency in all respects of the nuclear fuel cycle for peaceful purposes.[8]

The five approaches to nuclear fuel assurances are listed in Table 1.

Nonproliferation and energy security

A central premise links all of the regimes outlined above: that fuel assurances can contribute to nonproliferation by reducing national economic incentives to acquire sensitive nuclear facilities. By this reasoning, the availability of credible fuel assurances makes it more difficult for

Table 1. Five approaches to nuclear fuel assurances.

Approach	Major advocate	Distinguishing features
Centralist	USA (1946) (1977)	Planned allocation of fuel on a global basis.
Mercantilist	France (1960+)	Bilateral arrangements of exclusive character.
Two-tiered	USA (1978)	Creation of an exclusive international service sector for sensitive steps of the fuel cycle.
Modified two-tiered	UK and USA (1979)	As before, but with wider membership and emphasis on continued research and development on breeders and reprocessing.
Three-tiered	Argentina (1980)	Decentralization of the international market for nuclear technologies, services and fuel.

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[8] Final Document of the Preparatory Meeting of the Group of Non-Aligned Coordinating Countries on Peaceful Uses of Nuclear Energy, Belgrade, Yugoslavia, 4-6 December 1978, p 2.

a country to use economic arguments as a pretext for a political decision to acquire the means of building a nuclear weapon. Yet fuel assurances *per se* can only address part of the problem of nonproliferation and energy security. As INFCE pointed out, proliferation is mainly a political problem and is not always susceptible to technical or economic solutions. Furthermore, the long-term problems of national energy security confronting most nations are related far more to the price and availability of fossil fuels than to the economics of the nuclear fuel cycle. There are some particular circumstances, however, in which nuclear fuel assurances are more likely to contribute to the solution of both problems.

Status of the global market in nuclear fuels

The scarcer the world supply of uranium and enrichment services, the greater will be the potential role for fuel assurances as an instrument for pursuing energy security and nonproliferation. The key here is perceived availability rather than statistical estimation. If consuming nations have at their disposal a variety of suppliers to choose from, and abundant fuel supplies are reliably available, the leverage that specific suppliers will have over consumer policies will decline. In contrast, supplier influence will grow when consumers cannot find alternative supply arrangements. Both of these propositions follow from the basic idea that dependence buys influence.

The present fuel market is not encouraging with respect to the role fuel assurances can reasonably be expected to play as an instrument of nonproliferation policy wielded by suppliers over consumers. First, uranium is now cheap ($25.00/lb as of 31 May 1981)[9] and uranium reserve estimates and inventories of yellowcake are growing steadily. In light of reduced growth estimates for nuclear power, it is clear that uranium supply will exceed demand internationally to the year 2000 and possibly well beyond.[10] Second, with the entrance of URENCO, Eurodif and the USSR during the 1970s as major suppliers of enrichment services, the present oversupply of such services will probably continue until at least the early 1990s. The net result of these trends will be to reduce both the economic incentives for prematurely closing the nuclear fuel cycle and to reduce the dependence (and vulnerability) of consumers on fuel assurances from single suppliers. With this reduced dependence, once-privileged suppliers will be less able to shape the energy policies of consumers *via* the threat of interrupted supplies. In a soft fuel market, such threats would be neither credible nor effective.

Economic and political circumstances of specific countries

Fuel assurances will have greatest influence on the energy policies of countries anticipating a relatively large percentage of electricity generated by nuclear power, limited domestic nuclear resources, high external dependence on foreign technology and materials, and good prospects for economic growth. Brazil, South Korea, Taiwan and Spain are examples of countries in this category. Short of closing the nuclear fuel cycle (which perhaps only India can accomplish soon in the Third World), these countries must continue to rely extensively on foreign supplies of nuclear fuel and services. However, the leverage of single suppliers over the energy and security policies of consumer nations will be tempered by the multiplicity of suppliers on the market.

Although fuel assurances may, in the cases above, marginally affect the economics of alternative fuel cycles, it is not clear that economics deter-

[9] NUEXCO exchange value, May 1981. This compares with a peak exchange value of $43.50 in summer 1978.

[10] See Thomas L. Neff and Henry D. Jacoby, *Nuclear Fuel Assurance: Origins, Trends and Policy Issues*, MIT Energy Laboratory Report No MIT-EL 79-003, MIT, Cambridge, MA, February 1979. Also *idem*, *The International Uranium Market*, MIT Energy Laboratory Report No MIT-EL 80-014, December 1980.

mine national decisions to reprocess, enrich or breed nuclear fuel. In many countries (including Brazil, Argentina, Pakistan, India, Israel and South Africa), political factors weigh heavily in such decisions. Thus when the desire for autonomy, national prestige or a potential nuclear weapons option are driving local nuclear policy decisions, fuel assurances lose their value as an instrument of nonproliferation. The high economic cost of nationally closed fuel cycles is seen in these countries as more acceptable than the political and economic uncertainties that lie in continued dependence on foreign fuels and services. In such situations, cost comparisons of alternative fuel cycles appear rather irrelevant, because the basis of choice is not always economic merit but the pursuit of national economic and political autonomy.

For selected instances, where fuel assurances may serve as a useful tool of nonproliferation, the success of these measures depends upon the amount of confidence that consumer countries have in the reliability of the fuel market. There can be little confidence in a market in which suppliers apply retroactive conditions to fuel supply arrangements or disagree about the terms governing commerce in nuclear fuels. Confidence is increased when nuclear suppliers act predictably and in accordance with universally known criteria. In the words of the INFCE working group on fuel assurances,

> commercial markets for nuclear supply . . . have generally worked satisfactorily in recent years in terms of assurance of supply and they could probably do so in the future. Where cases of interruption or threatened interruption of nuclear exports have occurred in the past, they have . . . been in the context of governmental intervention in furtherance of economic and nonproliferation objectives. Such interruptions have caused delay and expense rather than damage to power production.[11]

Opportunities for unilateral governmental intervention arise from two political circumstances. First, domestic politics in supplier states can jeopardize fuel shipments by means of the nuclear export process. Examples of this include changes in Canadian nuclear export policy after the May 1974 nuclear explosion in India, and the opposition of the US Congress to the sale of fuel for India's Tarapur reactors. Second, consumers see undue intervention when certain suppliers (eg Canada, Australia and the USA) require full-scope safeguards and prior consent over the disposition of spent fuel, while other suppliers (eg France, the UK and West Germany) require no such conditions. The development of an international consensus on the conditions of trade would go far toward restoring the confidence of consumer countries in the fuel market, as would the development of a domestic consensus in supplier states on the contribution that fuel assurances can make to controlling proliferation.

Conclusions

The effectiveness and relevance of nuclear fuel assurances as instruments of nonproliferation policy vary with the status of the international market in uranium and nuclear fuel services and the special economic and political circumstances of consumer nations. Fuel assurances contribute to nonproliferation to the limited extent that they can influence local economic calculations about alternative nuclear fuel cycles.

To a nation determined to acquire nuclear weapons, however, nuclear fuel assurances will fail to address the fundamental political and military demands which motivate interest in a weapons capability. The margin of influence that suppliers will have over these nations is very low and will be limited to measures that affect the political environment giving rise to demands for nuclear weapons; such measures would include military assistance, alliance commitments, energy security arrangements and nuclear arms control agreements. As Thomas Schelling once said,

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[11] INFCE, Draft Final Report of Working Group 3, INFCE/WG 3/41, International Atomic Energy Agency, Vienna, 11 June 1979, p 11.

> it would be a . . . mistake to think that 'nonproliferation policies' are the most important policies for dealing with proliferation.[12]

There is at present very little international agreement on the structure of the market for nuclear fuel and services. A coherent international regime for fuel assurances will have to be based on a consensus of both suppliers and consumers about the degrees of uniformity and segmentation that will characterize the international market. Will there be a uniform code of conduct as illustrated in the 'centralist' scheme, or will the market be parcelled out on the basis of some political or economic formula as suggested in the other schemes? The most likely outcome will be the modified two-tiered scheme, coupled with continued international support for the rudimentary principles of nuclear commerce as set forth in NPT and IAEA guidelines. Movement toward a more uniform international code of conduct, perhaps combined with an international uranium commodity agreement, will have to await the development of a stronger international consensus on the relationship between fuel assurances and the energy security needs of consumers.

Another issue requiring further international discussion is the clarification of who will be subjects of the new fuel assurance regime. Nuclear fuel assurances are currently provided in one form or another by a variety of participants ranging from corporate, national and joint-venture, to international. Public utilities are now becoming active participants in uranium exploration and fuel 'swapping' which, without appropriate nonproliferation commitments, could have major impacts on the nonproliferation regime. Without the resolution of the problem of 'who is bound?' by international agreements, there cannot be a stable or effective regime.

Taken together, these steps constitute only a beginning. The ultimate relationship between future nuclear fuel assurances and nonproliferation will evolve from hard bargaining over the difficult political problems of who will get what from which regime. Nonetheless, given the alternative of an international *sauve-qui-peut* for sensitive fuels and technologies, the effort to build a global consensus on these issues is well worthwhile.

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[12] Thomas C. Schelling, Statement before US Senate Committee on Governmental Affairs, Subcommittee on Energy, Nuclear Proliferation and Federal Services, 4 April 1977, p 44.

Appendix 1

Statements on fuel assurances

. . . willingness to give supply assurances represents the most obvious 'bargaining chip' at the collective disposal of those suppliers preeminently concerned with nonproliferation.[1]
Ian Smart

Credible fuel assurances are essential if states are to forego the development of national enrichment and reprocessing facilities.[2]
Thomas Pickering

The unilateral suspension of deliveries by the supplier can lead to the unilateral suspension of the guarantees by the consumer.[3]
Carlos Castro Madero

The real proliferation danger could . . . result from reducing the possibility of, or denying altogether, easy and reliable access to commerically sensible, properly safeguarded nuclear technologies.[4]
Uranium Institute

A supply relationship buys influence in Third World intra-elite debates.[5]
Ashok Kapur

We reaffirm the importance of ensuring the reliable supply of nuclear fuel and minimizing the risk of nuclear proliferation.[6]
1980 Venice Communique

Fuel assurances cannot address all of the pressures which may induce a nation to acquire a sensitive technology, but they can address the accessibility and economics of nuclear fuels.[7]
NASAP

. . . fuel cycle leverage is a far-from-secure basis for nuclear foreign policy and . . . the traditional diplomatic, security, and other non-nuclear tools will remain the chief source of international influence in nonproliferation matters.[8]
Thomas Neff and Henry Jacoby

The Conference expressed its concern at the monopolistic policies of nuclear supplier countries restricting and limiting the transfer of technology and imposing conditions which are incompatible with the sovereignty and independence of developing countries.[9]
Sixth Conference of Heads of State of Non-Aligned Countries

A nonproliferation policy which reserved certain technologies essential to peaceful uses, for a small group of states or those equipped with nuclear weapons is unacceptable.[10]
Swiss delegate to 1980 NPT Review

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[1] Ian Smart, *Multinational Arrangements for the Nuclear Fuel Cycle*, Energy Paper No 43, Department of Energy, London, UK, January 1980.

[2] Thomas R. Pickering, *International Dimensions of Nonproliferation and of Safeguards in the 1980's*, remarks before the International Executive Conference on Nonproliferation and Safeguards, Mexico City, 9 September 1980.

[3] Carlos Castro Madero, Opening Address before the First Meeting of Non-Aligned Coordinating Countries for the Peaceful Uses of Nuclear Energy, Buenos Aires, 30 June 1980.

[4] Uranium Institute, *Prior Consent and Security of Supply in International Nuclear Trade*, Uranium Institute, London, UK, October 1980.

[5] Ashok Kapur, *International Nuclear Proliferation*, Praeger, New York, 1979.

[6] 1980 Venice Communique, Economic Summit.

[7] Nonproliferation Alternative Systems Assessment Program finding on nuclear fuel assurances for the INFCE.

[8] Thomas L. Neff and Henry D. Jacoby, *Nuclear Fuel Assurance*, MIT Energy Laboratory Report No MIT-EL-79-003, Cambridge, MA, February 1979.

[9] Final Declaration of the Sixth Conference of Heads of State of Non-Aligned Countries, Havana, September 1979.

[10] Statement of a Swiss delegate at the General Debate of Second Review Conference of Parties to the Nuclear Nonproliferation Treaty, 14 August 1980.

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Appendix 2

Specific policies to assure fuel supplies

- Diversified sources for supply of uranium ore and fuel services
- Uranium and low-enriched uranium (LEU) safety net arrangements (including INFCE's Uranium Emergency Safety Network)
- LEU fuel bank (for countries with small nuclear programmes)
- Expansion of US enrichment capability (Portsmouth)
- Prompt licensing of exports of special nuclear material (SNM)
- Reinforcement of national stockpiles of LEU and uranium
- Long-term contracts for nuclear fuel and/or services
- Reaffirmation of nonproliferation assurances
- Financial participation by consumers in fuel cycle activities (in the form of capital investment, management role, advance payments and loans in return for assured supplies)
- Fewer retroactive changes of conditions of supply
- *Pacta sunt servanda* (contracts will be fulfilled)
- Bilateral guarantees
- Reduction of uncertainties about the uranium resource base
- International Fuel Authority (long-term fuel allocation)
- Promotion of efficient use of LEU and enrichment techniques
- Stabilization of spot prices for U_3O_8